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**GATE Groupe d'Analyse et de Théorie Économique Lyon-St Étienne**

93, chemin des Mouilles 69130 Ecully – France

Tel. +33 (0)4 72 86 60 60

Fax +33 (0)4 72 86 60 90

6, rue Basse des Rives 42023 Saint-Etienne cedex 02 – France

Tel. +33 (0)4 77 42 19 60

Fax. +33 (0)4 77 42 19 50

Messagerie électronique / Email : [gate@gate.cnrs.fr](mailto:gate@gate.cnrs.fr)

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# How labor market rigidities shape business taxation in a global economy?\*

Nelly Exbrayat<sup>†</sup>, Carl Gaigné<sup>‡</sup> and Stéphane Riou<sup>§¶</sup>

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## Abstract

We investigate the impact of trade liberalization upon the taxation of capital within a context of labor market rigidities. Using a model of trade and location, we show that labor market imperfections not only strengthen tax competition but also affect the relationship between trade integration and tax policies. Capital taxation follows a J-shaped relationship with trade costs when labor markets are flexible, whereas it may increase with falling trade costs in the presence of trade unions acting as Stackelberg leaders or playing simultaneously with governments. In addition, we analyze the outcome which arises from differences between the various countries' labor market institutions. Trade liberalization reduces the international differences in wage and capital taxation, making the unionized country more attractive.

*Keywords:* Tax competition, unions, capital mobility, trade integration.

*JEL Classification:* F12, F16, H25

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<sup>†</sup>CERDI-CNRS, Université d'Auvergne.

<sup>‡</sup>INRA, UMR1302, SMART, 4, allée Bobierre, F-35000 Rennes.

<sup>§</sup>Université de Lyon, Lyon, F-69003, France ; Université Jean Monnet ; CNRS, GATE Lyon St Etienne, Saint-Etienne, F-42000, France.

<sup>¶</sup>Corresponding author. Stéphane Riou. E-mail: stephane.riou@univ-st-etienne.fr.

# 1 Introduction

It is now recognized that globalization forces may affect business tax policies by inducing higher tax base elasticities. Through a panel of 21 countries between 1982 and 1999, Devereux, Lockwood and Redoano (2008) show that the relaxation of capital controls puts more intense competitive pressure upon corporate tax rates. From data concerning 18 OECD countries over the period 1965-92, Rodrik (1997) finds that taxes on capital respond negatively to trade openness. There has also been wide theoretical discussion concerning the impact of economic integration upon corporate tax policies. Most of the papers in this strand of literature predict that globalization and capital mobility would engender a race to the bottom in taxation (Zodrow and Mieszkowski, 1986, Wilson, 1986, Wildasin, 1989).<sup>1</sup> Nevertheless, much of this literature has assumed perfect labor markets and full employment. We therefore fail to understand how the relationship between globalization and capital tax policies depends upon labor market characteristics.

In a paper related to ours, Hungerbühler and van Ypersele (2009) introduce profit and labor income taxation in a job search framework. Their model predicts that countries with less distorted labor markets would have a higher profit tax/labor income tax ratio than countries with severe labor market imperfections.<sup>2</sup> For the authors, this would be in accordance with the tax differential between US and France. More generally, countries with high levels of labor market imperfections would seek to compensate firms and capital by low profit tax rates. The present paper analyzes this compensation mechanism within a context of trade liberalization and aims to answer two main questions. Firstly, to what extent is the effect of distorted labor markets upon tax competition related to the level of trade integration between countries? Secondly, what is the tax competition outcome when countries are asymmetric with respect to their labor market institutions? Indeed, there are strong arguments for introducing both labor market imperfections and trade costs in a tax competition analysis.

Firstly, areas exhibiting intense tax interactions also often suffer from unemployment. It is commonly admitted that these two problems raise important policy issues in Europe. Various examples also suggest that adjustments of the corporate tax rates may be decided with the purpose of compensating for changes in the labor market legislation. In 1998,

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<sup>1</sup>For surveys, see Wilson and Wildasin (2004) and Wilson (1999).

<sup>2</sup>See also Leite-Montero, Marchand and Pestieau (2003), Lejour and Verbon (1986) Fuest and Huber (1999), Ogawa, Sato and Tamai (2006) for papers exploring the relationship between tax competition and labor market imperfections.

the United Kingdom introduced a national minimum wage for the first time (National Minimum Wage Act 1998) and, at the same time, decided to make significant corporate tax cuts. In May 2007, the US Congress approved the first increase in the federal minimum wage in nearly a decade (Fair Labor Standards Act 2007) but President Bush and Senate Republicans have made business tax breaks a condition for supporting this minimum wage increase<sup>3</sup>. Such a strategy has been also adopted by some Canadian provinces after increases in the minimum wage level (e.g. British Columbia in 2001, Ontario in 2003).

Secondly, it is commonly admitted that trade integration affects labor market outcomes. By inducing higher labor demand elasticities, trade integration may erode the bargaining power of labor vis-à-vis capital in the sharing of rents. As mentioned by Rodrik: *"The reason is that employers and the final consumers can substitute foreign workers for domestic workers more easily - either by investing abroad or by importing the products made by foreign workers "* (Rodrik, 1997, p. 16).<sup>4</sup> One might then wonder whether trade integration could lessen tax competition by reducing wage claims and mitigating the need for governments to compensate firms for labor market rigidities. We answer this question in this paper, by clarifying the impact of trade integration on business tax policies under wage rigidities.

To address our questions, we build a simple tax competition model with trade and imperfections on both labor and product markets. Our approach may be considered as an extension of economic geography literature with tax competition (Andersson and Forslid, 2003; Baldwin and Krugman, 2004; Gagné and Riou, 2007; Haufler and Wooton, 2010, Ottaviano and Van Ypersele, 2005). Indeed, all these papers consider perfectly competitive labor markets and inelastic labor supply. We assume that labor market rigidities arise from a monopoly union, whereas the product market is characterized by an oligopolistic industry where firms produce under increasing returns to scale. In addition, contrary to the conclusions offered in the standard literature concerning tax competition, decisions concerning the location of capital are not simply driven by costs factors (taxes and wages) but also by other economic considerations such as increasing returns, trade costs, and market structures (Head and Mayer, 2004). Finally, we adopt a game-theoretic approach where firms, governments, and unions act non-cooperatively and consider different sequences of events.

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<sup>3</sup>The two chambers accepted tax breaks worth \$8.3 billion over a period of 10 years. The previous increase in the US minimum wage in 1996 was also associated with 4,8 billion dollars worth of tax breaks.

<sup>4</sup>See also the literature on international unionized oligopolies (Naylor, 1998, 1999; Lommerud et al., 2003).

Our main results can be summarized as follows. We first show that the impact of trade integration on tax policies strongly depends upon the configuration of the labor market. When the labor market is competitive in both countries, the Nash capital tax rate follows a J-shaped relationship with trade costs. By contrast, when labor markets are unionized and unions act as Stackelberg leaders or play simultaneously with governments, trade integration may cause an increase in capital taxation. Indeed, falling trade costs raise the labor demand elasticity and thus reduce wage claims, so that governments are less incited to cut capital taxes in order to attract firms. Secondly, when countries differ with respect to their labor market institutions, the capital tax is lower in the unionized country but the resulting location of capital is *a priori* ambiguous. We show that a majority of capital is invested in the unionized country, provided that the relative importance of wages over employment for the trade union is not too high. Interestingly, trade liberalization leads to a convergence in wages and taxes, making the unionized country more attractive. The latter result remains valid whatever the timing of events. We therefore bring a new insight to the locational effects of asymmetric tax competition.

The rest of the paper is organized as follows. In the next section, we develop the model. In section 3, we analyze the tax competition outcome in the benchmark case, where both labor markets are competitive. In sections 4 and 5 respectively, we consider the existence of a monopoly union in both countries and an asymmetric configuration where the labor market is unionized in only one country. The robustness of the results is discussed in section 6. The last section concludes.

## 2 Model

The economy consists of two countries, labeled  $i = H, F$ . Variables associated with each country will be subscripted accordingly. Because we focus on the impact of labor market imperfections and trade liberalization upon tax policies, we control for any exogenous advantage by assuming countries with identical market sizes and the same technology. We denote by  $l$  the mass of workers/consumers living in each country. Each individual works and consumes in the country she lives in. Moreover, each resident is endowed with  $\bar{k}$  units of capital that she/he inelastically supplies. Thus, there are  $n \equiv 2l\bar{k}$  units of capital in the economy and capital is internationally mobile. Finally, the government of each country is benevolent and maximizes the total welfare of its residents by levying a lump-sum tax on capital ( $t_i$ ) on the source principle and a lump-sum tax on workers ( $\rho_i$ ).

## 2.1 Preferences

In order to make the model analytically tractable, we assume that all workers have the same quasi-linear utility with respect to a numéraire ( $z$ ), a homogeneous (manufactured) good, and the same disutility from labor<sup>5</sup>. Thus, a consumer residing in country  $i$  solves the following problem:

$$\underset{x_i^d, l_i^s}{Max} \ u_i \equiv \left(a - \frac{x_i^d}{2}\right) x_i^d + z - \frac{\eta}{2} (l_i^s)^2 \quad (1)$$

$$s.t. \quad y_i = x_i^d p_i + z \quad (2)$$

where  $a > 0$ ,  $x_i^d$  is the individual consumption level of the manufactured good,  $z$  is the individual consumption of the numéraire,  $l_i^s$  is the individual labor supply and  $\eta > 0$  is a measure for the preference for leisure. The variable  $y_i$  is the net income which depends on the status of the individual on the labor market:

$$y_i = \bar{z} + r\bar{k} + w_i l_i^s - \rho_i \text{ for employed workers} \quad (3)$$

$$y_i = \bar{z} + r\bar{k} + b_i \text{ for unemployed workers}$$

with  $\bar{z}$  the quantity of numéraire endowed by each worker,  $w_i$  the national wage rate, and  $r$  the world net return to capital. Thus,  $r\bar{k}$  denotes the individual net income of capital while  $w_i l_i^s$  is the individual labor income.<sup>6</sup> Finally,  $b_i$  are unemployment benefits for each unemployed individual, which are assumed to be exogenous. It should be noted that the numéraire is unproduced, costlessly tradable and the initial endowment  $\bar{z}$  is large enough for the individual consumption of the numéraire to be strictly positive at the market outcome<sup>7</sup>.

## 2.2 Technology and market structure

Firms produce a homogeneous product with increasing returns to scale and behave as Cournot competitors.<sup>8</sup> The production of the manufactured good requires a fixed amount

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<sup>5</sup>Although the income effect is erased with a quasi-linear utility, Dinopoulos et al. (2007, p.22), show that this type of preferences behave reasonably well in the models of international trade.

<sup>6</sup>Hence, residents are both workers and capital owners. This assumption is standard in the tax competition literature, even in the presence of unemployment (see Ogawa *et al.*, 2006; Fuest and Huber, 1999; Richter and Schneider, 2001).

<sup>7</sup>The model can easily be extended by introducing a second sector producing the numéraire under constant returns and perfect competition, using a specific factor that is in fixed supply.

<sup>8</sup>Using a monopolistic competition model of economic geography à la Ottaviano and Van Ypersele (2005) does not qualitatively change the results. Without product differentiation, the equilibrium prices are lower but react in the same way to a change in trade costs and the spatial distribution of firms.



$f$  of labor units and one unit of capital, so that  $n$  is also the number of firms in the economy. Shipping the manufactured good is costly. Specifically, firms incur a trade cost of  $\tau > 0$  units of the numéraire per unit of good shipped between the two countries. We assume that product markets are segmented and that labor markets are national. Each firm determines a quantity specific to the country in which it sells its output and wages can differ from one country to another because workers are internationally immobile. Hence, quantities, prices, and wages are specific to each country but interdependent because of capital mobility.

The operating profits of a firm located in country  $i$  are given by

$$\Pi_i = p_i x_{ii} + (p_j - \tau) x_{ij} \quad (4)$$

where  $x_{ii}$  is the quantity that it supplies to domestic consumers,  $x_{ij}$  is the quantity it sells to foreign consumers and  $p_i$  is the price prevailing in country  $i$ . Thus, its net profits are expressed as follows:

$$\pi_i = \Pi_i - f w_i - r_i - t_i \quad (5)$$

where  $r_i$  is the rental rate of capital in country  $i$ . In the long run,  $r_i$  is equalized across countries due to capital mobility.

## 2.3 Labor market regimes

We consider two types of wage setting regimes: a competitive labor market, and a trade union. The latter regime induces a higher wage than the competitive wage thereby generating unemployment.

**A. Wage flexibility** Under the competitive labor market regime, the equilibrium wage is simply determined by the labor market clearing condition which will be described in section 3.1.

**B. Monopoly union** Three types of models with unionized labor markets are currently considered in the literature on trade unions: the monopoly union model, the wage bargaining model and efficient bargaining models (see. Oswald, 1985). Here, we choose the first alternative where the labor market is dominated by a monopoly union which chooses a wage for all firms in the country subject to the labor demand function. The monopoly union can be seen as a special case because unions hold all the bargaining power. Nevertheless, our purpose being to highlight the way in which trade integration may affect the

relationships between labor market rigidities and capital taxation, it is reasonable in a first approach to assume two polar labor market regimes.<sup>9</sup> Moreover, the combination of linear Cournot oligopoly and monopoly unions is commonplace in the literature.<sup>10</sup> Union preferences are characterized by the following Stone-Geary-type utility function:

$$U_i = (w_i^u - \bar{w})^\mu (L_i^d)^{1-\mu} \quad (6)$$

with  $w_i^u$  the nominal wage rate set by the union in country  $i$ ,  $L_i^d$  the level of employment in country  $i$ , and  $\bar{w}$  the reservation wage rate<sup>11</sup>. As emphasized by Cahuc and Zylberberg (1991), the objective function above is a simple way of considering that unions are concerned by both wages and employment and it also avoids assigning an arbitrary value to the preference of unions. Hence, the parameter  $\mu \in (0, 1)$  represents the relative importance of wages over employment for the trade union. Moreover, this general specification allows us to address the standard rent maximization hypothesis with  $\mu = 0.5$  (see. Naylor, 1998, 1999; Straume, 2003; Lommerud *et al.*, 2003).

## 2.4 Governments

Governments maximize the welfare of their residents by non-cooperatively choosing the per-unit tax on capital ( $t_i$ ) and on employed workers ( $\rho_i$ ). Following Persson and Tabellini (1992) in assuming that taxes exist only for the purpose of redistributing income, we disregard efficiency considerations of public good provision. Given the one-to-one correspondence between firms and capital, the budget constraint is given by:

$$t_i n_i + \rho_i l_i^e = b_i l_i^u \quad (7)$$

where  $l_i^e$  is the number of workers in employment whereas  $l_i^u$  is the number of unemployed workers. Inserting (2), (3) in (1) and after rearrangements, we obtain the aggregate welfare in each country:

$$W_i = l S_i + r \bar{k} l + l_i^e \left[ w_i l_i^s - \frac{\eta}{2} (l_i^s)^2 - \rho_i \right] + l_i^u b_i + \text{constant} \quad (8)$$

where  $S_i$  denotes the consumer's surplus. The national welfare is the sum of six terms: total consumers' surplus, capital income, labor income, disutility from labor, labor tax

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<sup>9</sup>The assumption that workers are shareholders would be problematic for the two other types of model. In this case, both parties would negotiate for the same interest.

<sup>10</sup>Examples are Bughin and Vannini (1995), Lejour and Verbon (1996), Leahy and Montagna (2000), Lommerud *et al.* (2003), Naylor (1998, 1999), Straume (2003), Richter and Schneider (2001), and Leite-Monteiro *et al.* (2003).

<sup>11</sup>It is assumed that unions have perfect information about the labor demand function.

income, benefits to unemployed residents and a constant equal to the total endowment of numéraire. Therefore, the maximization program of governments is tightly related to the labor market performance. When the labor market is competitive,  $l_i^u = 0$  and  $l_i^e = l$ , while  $l_i^u > 0$  and  $l_i^e < l$  (with  $l_i^u + l_i^e = l$ ) under labor market imperfections. When the wage is higher than the competitive wage, we obtain  $L_i^d = l_i^s l_i^e$  where  $l_i^s$  stands for labor units supplied by each worker so that

$$l_i^e = L_i^d / l_i^s. \quad (9)$$

## 2.5 Sequence of events

The model consists of a sequential game where the players are workers, firms, governments and trade unions. In the absence of trade unions, each government decides the level of its per-unit tax on labor and capital in the first stage of the game, taking as given the decision of the other government and anticipating the resulting location equilibrium as well as the private sector outcome. In the second stage, residents choose the location of their capital investment given the tax policy choices announced by governments and anticipating the private sector outcome. In the last stage, firms and residents make their production, consumption and labor allocation choices, respectively, taking as given the level of taxes chosen by governments.

In the presence of trade unions and governments, three possible configurations should be considered: the union is a Stackelberg leader, the government is a Stackelberg leader, and both play Nash. The choice of the most representative sequence of events can be related to the duration of the policy set by each player. As Hersoug (1985) argued, union can be considered as a leader as wage contracts often have a longer duration than one year whereas changes in the tax policy would occur more frequently. There is however, no consensus on this point. Clearly, the game can also be related to the relative strength of the players and this brings us back to the degree of centralization of the wage setting (Boeters and Schneider, 1999). Our model being based on a highly centralized wage setting, it seems reasonable to assign the role of the Stackelberg leader to the monopoly union as a benchmark case. Alternatively, the case where both parties decide simultaneously might be plausible. This last case is reported in the Appendix where we show that it yields fairly similar results. To complete our robustness analysis, a third case where governments act as Stackelberg leaders is also described in the Appendix and the results are rigorously compared with the two first configurations.

### 3 Tax competition with perfectly competitive labor markets

We first describe the tax competition outcome in the benchmark case without labor market imperfections. The game is solved by a sub-game perfect Nash equilibrium involving backward induction beginning with the last stage.

Let  $0 \leq \lambda \leq 1$  stand for the share of capital in country  $H$ .<sup>12</sup> In order to disentangle the various effects at work, we distinguish between what we call a short-run equilibrium, in which capital is supposed to be immobile, i.e.  $\lambda$  is exogenous; and a long-run equilibrium where it is mobile, i.e.  $\lambda$  is endogenous. We first present the product and labor market outcomes in the short-run. Then, we describe capital location and governments' tax policy in the long-run.

#### 3.1 Product and labor market outcomes (stage 3)

Given (1) and (2), the individual demand for the manufactured good in country  $i$  is given by  $x_i^d = a - p_i$ . In addition, maximizing (5) with respect to  $x_{ii}$  and  $x_{ij}$  yields the following quantity choices at the equilibrium:  $x_{ii} = lp_i$  and  $x_{ij} = l(p_j - \tau)$ . Thus, the supply to the domestic market depends exclusively upon the market size (constant in both countries) and upon the price at which goods are sold in each market. Additionally, the supply to the foreign market decreases with the level of trade barriers. Finally, the market-clearing condition of the manufacturing sector requires that  $(a - p_i)l = n_i x_{ii} + n_j x_{ji}$  where  $n_i$  is the mass of firms or capital located in country  $i$ . Hereafter, we denote by a subscript \* variables at the short-run equilibrium. Solving the market-clearing condition gives the equilibrium price in country  $i$ :

$$p_i^* = \frac{a + \tau n_j}{1 + n} \quad (10)$$

The price in country  $i$  increases with trade barriers, because the local firms are more protected against foreign competition, and with the mass of firms located abroad because, in this case, the local competition is less intense. These prices lead to the following operating profits:

$$\Pi_i^* = (p_i^*)^2 l + (p_j^* - \tau)^2 l \quad (11)$$

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<sup>12</sup>Hereafter, the terms 'capital' and 'firms' are indifferently used as a firm needs one capital unit to produce.

We assume that the trade cost is non-prohibitive so that prices net of trade costs are positive whatever the spatial distribution of firms:

$$\tau < \tau_{trade} \equiv \frac{a}{1+n}.$$

We now turn to the labor market outcome. By inserting the budget constraint (2) in the resident's utility function (1) and maximizing the resulting expression with respect to  $l_i^s$ , we get the following equilibrium individual labor supply in country  $i$ :

$$l_i^s = w_i/\eta \quad (12)$$

so that the total supply of labor units is given by  $lw_i/\eta$ . Hence, our approach differs from existing models of trade and location with tax competition where labor supply is inelastic. In our framework, individual labor supply depends upon wages and the disutility from labor. The national demand for labor units, related to the requirement of labor and the number of firms, is given by:

$$L_i^d = fn_i \quad (13)$$

Thus, the labor market clearing condition yields the following wage rate equilibrium in country  $i$ :

$$w_i^{cc,*} = fn_i/l \quad (14)$$

where the subscript  $^{cc}$  stands for the description of the outcome when labor markets are competitive in both countries. Clearly, the competitive wage prevailing in a country is a decreasing function of the number of workers and an increasing function of the number of firms located in this country.

### 3.2 Location of capital (stage 2)

Due to free entry and exit, there are no profits in equilibrium. The equilibrium rental rate in each country is thus determined by a bidding process for capital, which ends when no firm can earn a strictly positive profit at the equilibrium market price:

$$r_i^* = \Pi_i^* - fw_i^{cc,*} - t_i^{cc}. \quad (15)$$

The location of capital is governed by the spatial difference in net returns to capital (15), evaluated at equilibrium prices (10) and wages (14). A spatial equilibrium  $\lambda \in (0, 1)$  (with  $n_H = \lambda n$  and  $n_F = (1 - \lambda)n$ ) is such that no unit of capital can induce a higher return by being invested in another country. Formally, an interior equilibrium arises at  $\lambda^{cc} \in (0, 1)$

when  $\Pi_H^*(\lambda^{cc}) - fw_H^{cc,*}(\lambda^{cc}) - t_H^{cc} = \Pi_F^*(\lambda^{cc}) - fw_F^{cc,*}(\lambda^{cc}) - t_F^{cc}$ . Solving this equality with respect to the share of capital invested in country  $H$  ( $\lambda^{cc}$ ) yields the location equilibrium for given taxes:

$$\lambda^{cc} = \frac{1}{2} - \frac{(1+n)(t_H^{cc} - t_F^{cc})}{4nl\tau^2 + 2\eta f^2(1+n)n/l}. \quad (16)$$

Some comments are in order. The location equilibrium is mainly the result of three mechanisms. The first is standard and known in the economic geography literature as a pro-competitive effect. When a country hosts new firms/capital, existing domestic firms face more competitors in their domestic market and fewer in the foreign one. Thus, the domestic price falls whereas the foreign price rises (see 10). Domestic sales generate more revenues than foreign sales because of the trade cost (see 11), so that this effect acts as a dispersion force. The pressure on the cost of labor induced by the agglomeration of firms is the second force affecting the international allocation of capital. Indeed, the attractiveness of the country with the fiscal advantage is moderated for high fixed requirements in labor ( $f$ ) and high disutility from labor ( $\eta$ ). In this case, the fiscal advantage is counteracted by a strong wage pressure which incites firms to relocate. Finally, the location choice is affected by the tax wedge. Unsurprisingly, a unilateral rise in capital taxation in a country leads to an outflow of capital from this country ( $d\lambda^{cc}/dt_H^{cc} < 0$ ).

The tax base elasticity in country  $H$  is given by:

$$\varepsilon_H^{cc}(\tau) = -\frac{\partial \lambda^{cc}}{\partial t_H^{cc}} \frac{t_H^{cc}}{\lambda^{cc}} = \frac{(1+n)t_H^{cc}}{2nl\tau^2 + \eta f^2(1+n)n/l - (1+n)(t_H^{cc} - t_F^{cc})}$$

and the tax base elasticity in country  $F$  can be derived by symmetry. Clearly, trade integration makes capital more responsive to a change in the tax wedge ( $d\varepsilon_i^{cc}/d\tau < 0$ ). Observe from (10) that prices become less and less sensitive to the spatial distribution of firms as trade costs decrease. Through this effect, trade integration weakens the dispersion force associated with price competition and strengthens the weight of taxes in the capital location choice. Stated differently, even small changes in the relative costs of doing business can induce important changes in capital location as the world economy is becoming more closely integrated.

It is also worth stressing that the tax base elasticity is weakened by high levels in labor input requirement and in disutility from labor, both raising the equilibrium wage. More generally, when country  $i$  decreases its capital taxation, the resulting capital inflow increases the wage cost by shifting labor demand upwards. In other words, the attractiveness effect of a tax cut is limited by the upward adjustments of the wage rate.

### 3.3 Equilibrium tax policies (stage 1)

We now solve the first stage of the game and characterize the subgame perfect Nash equilibrium (the subscript  $\sim$  refers to variables evaluated at the subgame perfect Nash equilibrium). When the labor market is competitive,  $l_i^u = 0$  and  $l_i^e = l$ , so that the government's budget constraint amounts to:

$$-\rho_i l = t_i \lambda_i^{cc} n \quad (17)$$

Since budgets have to be balanced, the policy problem faced by each government is one-dimensional: the choice of the capital tax rate determines the tax rate on workers required to satisfy the budget constraint.

Inserting the equilibrium level of labor supply (12), prices (10) and competitive wage rates (14) in the welfare function (8), with the constraints that  $l_i^u = 0$  and  $l_i^e = l$ , the objective function of each government amounts to:

$$W_i^{cc} = l S_i^* + \frac{n}{2} r^* + t_i \lambda_i^{cc} n + l \frac{(w_i^{cc,*})^2}{2\eta} + \text{constant} \quad (18)$$

where  $r^*$  represents the net return to capital at the location equilibrium while the fourth term represents the gross total wages of residents minus their disutility from labor. The consumer surplus  $S_i^*$ , evaluated at equilibrium price in country  $i$ , is given by:

$$S_i^* = \frac{1}{2} \frac{n^2 (a - \tau (1 - \lambda_i^{cc}))^2}{(1 + n)^2} \quad (19)$$

Before proceeding further with the analysis, we isolate how each component of the aggregate welfare reacts in response to a tax variation. Let us first consider the effect of a variation of capital taxation on the domestic consumer's surplus. By introducing the location equilibrium in (19), we can easily show that in order to lower prices in its domestic market each government has an incentive to set a low tax burden on capital:

$$\frac{dS_i^*}{dt_i} = \frac{\partial S_i^*}{\partial p_i^*} \frac{\partial p_i^*}{\partial \lambda_i^{cc}} \frac{\partial \lambda_i^{cc}}{\partial t_i^{cc}} < 0.$$

Secondly, the effect of a marginal variation of  $t_i$  on the net return to capital is given by:

$$\frac{dr^*}{dt_i} = \underbrace{\frac{\partial \Pi_i^*}{\partial p_i^*} \frac{\partial p_i^*}{\partial \lambda_i^{cc}} \frac{\partial \lambda_i^{cc}}{\partial t_i^{cc}}}_{+} - f \underbrace{\frac{\partial w_i^{cc}}{\partial \lambda_i^{cc}} \frac{\partial \lambda_i^{cc}}{\partial t_i^{cc}}}_{+} - 1.$$

This expression encapsulates one direct effect and two indirect effects. We first focus on the indirect effects. By inducing more price competition among firms, a tax cut reduces

the operating profits. In addition, when a unilateral tax cut is decided the labor demand shifts upwards and the cost of labor rises. Hence, *an unilateral decrease in corporate tax gives rise to a lower gross-of-tax capital income*. Nevertheless, as expected, a lower tax burden has a direct positive effect on the net capital income.

Depending on the sign of  $t_i^{cc}$ , the third term in (18) describes the capital tax revenues or the fiscal contribution of workers as taxation is assumed to be redistributive. Formally, we have

$$\frac{d(t_i \lambda_i^{cc} n)}{dt_i^{cc}} = \lambda_i^{cc} n + t_i^{cc} n \frac{\partial \lambda_i^{cc}}{\partial t_i^{cc}} = \lambda_i^{cc} n (1 - \varepsilon_i^{cc}).$$

Again, the net effect of a unilateral tax change is ambiguous. Starting from positive capital taxation, the tax base elasticity has to be low enough in order to allow a rise in the capital tax to increase capital tax revenues.

Finally, we can investigate the effect of the tax policy upon the labor market component of the welfare equation, that is the gross labor incomes minus the disutility from labor. After substitutions and simplifications, we obtain

$$\frac{d(l(w_i^{cc,*})^2/2\eta)}{dt_i^{cc}} = \frac{f^2 \eta n^2}{2l} \frac{\partial (\lambda_i^{cc})^2}{\partial t_i^{cc}} < 0$$

Clearly, reducing the tax burden on capital positively affects the wage rate net of the disutility from labor. The mechanism at work is simple: a tax cut generates an inflow of capital that increases the level of the competitive wage.

Maximizing (18) with respect to  $t_i^{cc}$ , we get the equilibrium tax on capital in each country

$$t_i^{cc} = -\frac{nl\tau [2a - \tau(2n + 3)]}{2(1 + n)^2} \equiv \tilde{t}^{cc}. \quad (20)$$

Trivial calculations reveal  $\tilde{t}^{cc} > 0$  as long as  $\tau > \bar{\tau}$  with

$$\bar{\tau} \equiv \frac{2a}{2n + 3} < \tau_{trade}.$$

Below a threshold level of trade costs ( $\bar{\tau}$ ), governments subsidize capital and tax the labor income. Furthermore, capital taxes describe a J-shaped curve with respect to  $\tau$  since  $d\tilde{t}^{cc}/d\tau \gtrless 0$  when  $\tau \gtrless \bar{\tau}/2$ . Starting from high trade costs ( $\tau \geq \bar{\tau}$ ), a gradual fall in trade barriers reduces capital taxes. When trade liberalization reaches intermediate levels ( $\bar{\tau} > \tau > \bar{\tau}/2$ ), governments subsidize capital. Hence, the subsidy level rises as trade costs decline further. Nevertheless, when trade costs reach  $\bar{\tau}/2$ , the cost for workers to finance higher subsidies for firms exceeds the benefits they enjoy from this policy. Consequently, the subsidy level for capital shrinks and  $\tilde{t}^{cc}$  tends to zero when trade



liberalization approaches free trade. Put differently, *tax competition is relaxed when trade costs reach low values*<sup>13</sup>.

Given the perfect symmetry of the model, the location equilibrium is symmetric (that is,  $\tilde{\lambda}^{cc} = 1/2$ ). Inserting it into the competitive wage (14), we get the level of wages  $\tilde{w}^{cc}$  in each country at the location equilibrium:

$$\tilde{w}_H^{cc} = \tilde{w}_F^{cc} = \frac{f\eta n}{2l} \equiv \tilde{w}^{cc} \quad (21)$$

## 4 Tax competition with a unionized labor market in both countries

We now extend our basic model to the case where the wage setting is centralized and a monopoly union operates as Stackelberg leader in each country. Therefore, our model is now a fourth-stage game. The product market outcome arising at the fourth stage of the game is given by expressions (11) and (10) (Section 3.1). In the following subsections, we solve the previous stages where firms make their location choices (section 4.1), governments set their tax policy (section 4.2), and trade unions set wages (section 4.3).

### 4.1 Capital location and tax base elasticities (stage 3)

Let  $\lambda^{uu}$  denote the share of capital located in country  $H$  when both labor markets are unionized. The choice of capital location is made for given levels of wages chosen by unions ( $w_i^{uu}$ ) and given corporate taxes in each country ( $t_i^{uu}$ ). Thus, the location equilibrium arises when  $\Pi_H^*(\lambda^{uu}) - t_H^{uu} - f w_H^{uu} = \Pi_F^*(\lambda^{uu}) - t_F^{uu} - f w_F^{uu}$ . Solving this equality with respect to  $\lambda^{uu}$  yields the following location equilibrium:

$$\lambda^{uu}(t_i^{uu}, w_i^{uu}) = \frac{1}{2} - \frac{(1+n)[f(w_H^{uu} - w_F^{uu}) + t_H^{uu} - t_F^{uu}]}{4l\tau^2 n}. \quad (22)$$

From this expression, we can deduce the tax base elasticity for capital invested in country  $H$ :

$$\varepsilon_H^{uu}(\tau) = -\frac{\partial \lambda^{uu}}{\partial t_H^{uu}} \frac{t_H^{uu}}{\lambda^{uu}} = \frac{t_H^{uu}(n+1)}{2ln\tau^2 - (n+1)(t_H^{uu} - t_F^{uu}) - f(w_H^{uu} - w_F^{uu})(n+1)} \quad (23)$$

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<sup>13</sup>Interestingly, we thereby show that the J-shaped relationship between capital taxes and trade costs, which was first demonstrated in the tax competition literature based on NEG models with a constant wage (Ludema and Wooton, 2000; Kind et al., 2000; Ottaviano and van Ypersele, 2005; Haufler and Wooton, 2010), also holds when wages increase with the number of domestic firms.

and a symmetrical expression holds for the tax base elasticity in country  $F$ . As in the benchmark case with competitive labor markets, a unilateral increase in the capital tax yields a capital outflow. However, we have  $\varepsilon_i^{uu}(\tau) > \varepsilon_i^{cc}(\tau)$  at the symmetric equilibrium ( $w_H^{uu} = w_F^{uu}$ ). Indeed, the positive impact of agglomeration upon wages in a flexible labor market disappears in the presence of trade unions. For the same reason, trade integration makes capital location more responsive to taxes than in the case of perfectly competitive labor markets ( $d\varepsilon_i^{uu}/d\tau < d\varepsilon_i^{cc}/d\tau < 0$ ).<sup>14</sup>

## 4.2 Nash tax policies (stage 2)

Because of distortions on the labor market, each government is now faced with two categories of households depending upon their position in the labor market (employed or unemployed). Labor tax is levied exclusively on employed residents and each national government provides benefits  $b$  to unemployed residents. As a result, the government's budget constraint in country  $i$  amounts to:

$$t_i^{uu} \lambda_i^{uu} n + \rho_i l_i^e = b_i(l - l_i^e) \quad (24)$$

where  $l_i^e = L_i^d/l_i^s = \eta f \lambda_i^{uu} n / w_i^{uu}$ . This leads to intuitive relationships: unemployment increases with the wage set by the unions while it decreases with the number of firms, the fixed requirement of labor and the preference for leisure. With (24) and after rearrangements, the objective function of each government is given as:

$$W_i^{uu} = l S_i^* + \frac{r^* n}{2} + t_i^{uu} n \lambda_i^{uu} + \frac{1}{2} \frac{(w_i^{uu})^2}{\eta} l_i^e + \text{constant} \quad (25)$$

where  $\lambda_i^{uu}$  is given by equation (22) for  $i = H$ . At this stage, the wage rate is exogenous and governments cannot influence the wage claims of the domestic union by manipulating taxes accordingly in order to affect the location of capital. Nevertheless, the tax policy will have a direct effect on the spatial distribution of capital and then on the number of workers employed  $l_i^e$ . By maximizing (25) with respect to  $t_i$  for each government, we get the following Nash tax equilibrium:

$$t_i^{uu} = t^{cc} + \frac{f [w_j^{uu} (2n + 3) - w_i^{uu} (10n + 13)]}{4(4n + 5)} \quad (26)$$

with  $j \neq i$ . Several comments are in order. First, for given wages, the tax rate in each country reacts to a change in trade costs in exactly the same way as when both labor

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<sup>14</sup>Intuitively, this analysis is also valid in the case of an exogenous wage in each country and more generally for all wage rigidities such that agglomeration has no impact upon the cost of labor.

markets are competitive ( $dt_i^{uu}/d\tau \geq 0$  when  $\tau \geq \bar{\tau}/2$ ,  $\forall i = H, F$ ). Secondly, the tax rate in a country decreases with the national wage rate and increases with the wage rate of its trading partner ( $dt_i^{uu}/dw_i^{uu} < 0$  and  $dt_i^{uu}/dw_j^{uu} > 0$ ). Thus, the intensity of tax competition is closely related with the labor market outcome and this preliminary result illustrates the possibility of using taxation to compensate firms for high labor costs.

### 4.3 Equilibrium wage rates (stage 1)

Having described the optimal choice of tax rates by governments, we can solve the maximization program of monopoly unions to define the equilibrium wage rate in each country. Each labor union sets  $w_i^{uu}$  non-cooperatively to maximize (6) with  $L_i^d = fn\lambda_i^{uu}(w_i^{uu}, w_j^{uu})$  by anticipating capital location and the tax choices made by governments. Hence, in stage 1, the share of capital located in country  $H$  is now given by:

$$\lambda^{uu}(t_i^{uu}, w_i^{uu}) = \frac{1}{2} - \frac{(w_H^{uu} - w_F^{uu})(1+n)^2 f}{4(4n+5)l\tau^2 n} \quad (27)$$

where we have introduced (26) in (22).

Let us first look at the resulting labor demand schedule and its responsiveness to trade integration. Inserting this location equilibrium in the national labor demand function  $L_i^d$ , we can verify that a high wage reduces labor demand ( $dL_i^d/dw_i^{uu} < 0$ ). Nevertheless, we can observe that the response of labor demand to wages is the result of two opposite forces. First, high wages have a standard negative effect in terms of attractiveness, which causes a decrease in the labor demand. Secondly, monopoly unions anticipate that high wages lead the government to set low taxes on capital (see 26). Thus, the negative impact upon the attractiveness of high wage claims is moderated by the tax adjustment. Formally, the labor demand elasticity with respect to the wage rate in country  $i$  is expressed as follows:

$$\xi_i = -\frac{dL_i^d}{dw_i^{uu}} \frac{w_i^{uu}}{L_i^d} = \frac{w_i^{uu} f (1+n)^2}{2ln\tau^2 (4n+5) - f (1+n)^2 (w_i^{uu} - w_j^{uu})}$$

with  $\xi_i > 0$  at the symmetric equilibrium. We can observe that  $\xi_i$  decreases with  $\tau$ . In other words, trade integration increases the labor demand elasticity. Interestingly, this result illustrates Rodrik's intuition that "*trade increases the degree to which employers can react to changes in prevailing wages by outsourcing or investing abroad*" (Rodrik, 1997, p. 12-13).

Now, we can describe the trade-off for monopoly unions. While choosing high wages increases the workers' gross income, it reduces labor demand and leads more people to

become unemployed. The total effect of a wage increase on the wage bill depends upon the relative strength of each effect. Inserting the labor demand function into the monopoly union's objective function and maximizing the corresponding expression with respect to  $w_i^{uu}$ , we get the following reaction function for the trade union in country  $i$ :

$$w_i^{uu} = \mu w_j^{uu} + (1 - \mu)\bar{w} + \mu \frac{2l\tau^2 n(4n + 5)}{f(n + 1)^2}$$

Consequently, the equilibrium wage rates are given by:<sup>15</sup>

$$\tilde{w}_H^{uu} = \tilde{w}_F^{uu} = \bar{w} + \frac{\mu}{1 - \mu} \frac{2l\tau^2 n(4n + 5)}{(1 + n)^2 f} \equiv \tilde{w}^{uu} \quad (28)$$

Interestingly, the wage rate declines with trade integration ( $d\tilde{w}^{uu}/d\tau > 0$  and  $d^2\tilde{w}^{uu}/d\tau^2 > 0$ ). By increasing the labor demand elasticity to the wage rate, trade integration forces trade unions to lower the wage rates in order to reduce the negative effect of a high wage on labor demand and the resulting level of employment. This result is the opposite of that which was found by Naylor (1998), according to which wages increase with trade integration when the spatial distribution of firms is exogenous. Thus, ignoring the fact that high wages might deter investments, Naylor's model cannot capture the effect of trade costs on the aggregate labor demand elasticity. The only channel through which trade costs affect labor demand comes from the positive impact of a decline in trade costs upon the total output and employment of each firm. Within our framework, we do not capture this effect because we consider that the marginal labor requirement equals to zero. This allows us to isolate and determine how the relationship between trade integration and wages can be affected by capital mobility and its impact upon the demand for labor. In this way, trade integration increases the tax base elasticity and, *in fine*, raises the labor demand elasticity, in accordance with empirical studies. Indeed, from US data, Slaughter (2001) shows that the demand for production labor has become more elastic in manufacturing: the elasticity reached -0.5 by the mid-1970s and around -1.0 in 1991. Hasan *et al.* (2007) also show that labor demand elasticities within the manufacturing sector rose after the trade reforms in India. To summarize our results,

**Proposition 1** *Assume monopoly unions in each country playing as Stackelberg leaders. Under capital tax competition, the equilibrium wage rate set by unions decreases with trade integration.*

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<sup>15</sup> At these levels of equilibrium wages, the second-order condition is checked.

Having determined the equilibrium level of wages in each country, we can evaluate the capital taxes at the subgame perfect Nash equilibrium (SPNE). By introducing (28) in (26), we get:

$$\tilde{t}_i^{uu} = \tilde{t}^{cc} - \frac{f\bar{w}}{2} - \frac{\mu}{1-\mu} \frac{l\tau^2 n(5+4n)}{(1+n)^2} \equiv \tilde{t}^{uu}$$

with  $\tilde{t}^{uu} < \tilde{t}^{cc}$ . Clearly, a more aggressive tax policy takes place to compensate firms for wage rigidity. As expected, the higher the importance attached to the wage in the union's objective function, the lower the level of capital tax ( $d\tilde{t}^{uu}/d\mu < 0$ ). Moreover, the existence of a trade union implies that the configuration where workers become the net-contributors of the public sector emerges earlier in the process of trade integration.

**Proposition 2** *Assume monopoly unions in each country both playing as Stackelberg leaders. A shift from a flexible labor market to a unionized labor market strengthens capital tax competition, regardless of trade costs.*

How do capital taxes at the SPNE react to trade integration? Some calculations reveal that the equilibrium level of the capital tax rate increases with trade integration provided that the relative importance of wages over employment for the trade union is high enough. Indeed, we have:

$$\frac{d\tilde{t}^{uu}}{d\tau} < 0 \text{ iff } \frac{\mu}{1-\mu} > \frac{(2n+3)(\tau - \bar{\tau}/2)}{2(4n+5)\tau}.$$

Hence, when  $\tau < \bar{\tau}/2$ , both  $\tilde{t}^{cc}$  and  $\tilde{t}^{uu}$  increase with trade integration. However, when  $\tau > \bar{\tau}/2$ , a fall in trade costs decreases  $\tilde{t}^{cc}$  but raises  $\tilde{t}^{uu}$  if and only if  $\mu$  is above a threshold level  $\check{\mu}$  with

$$\check{\mu} = \frac{a - \tau(2n+3)}{a - \tau(10n+13)}$$

The latter relationship arises for the following reason. The third term in (??) captures the negative effect of the wage set by unions on corporate tax, and this effect is magnified by high levels of  $\mu$ . Thus, provided that  $\mu$  is high enough, the erosion of this negative wage effect on taxation due to trade integration counterbalances the opposite direct effect on  $\tilde{t}^{cc}$ . Hence, contrary to the configuration with a competitive wage, trade integration always relaxes tax competition when  $\mu$  is high enough. This scenario occurs, for example, under the rent maximization hypothesis. By contrast, when the importance attached to the employment in the union's objective function is relatively high, wages tend to be closer to the reference wage rate ( $\bar{w}$ ) so that the magnitude of the changes in wages is lower and trade integration intensifies tax competition. The subgame perfect Nash tax equilibrium is thus less dependent upon the labor market outcome and increases with trade costs.

To summarize:

**Proposition 3** *Assume monopoly unions in each country both playing as Stackelberg leaders. When trade costs are above  $\bar{\tau}/2$ , trade openness relaxes (resp. strengthens) capital tax competition, provided that the relative importance of wages over employment for unions is high (resp. low) enough. Once trade costs decline below  $\bar{\tau}/2$ , trade integration relaxes capital tax competition regardless of the relative importance of wages over employment for unions.*

To complete our analysis, we briefly investigate the level of unemployment and labor tax at the SPNE. Assume that the reservation wage is equal to the competitive wage given by (21). The number of unemployed people in each country is given by:

$$\tilde{l}_i^u = \frac{4l^3\mu(4n+5)\tau^2}{\tau^2 4l^2\mu(4n+5) + f^2\eta(n+1)^2(1-\mu)} > 0 \quad (29)$$

It is worth noting that as trade integration results in a lower wage set by the union, it also reduces unemployment in the economy ( $d\tilde{l}_i^u/d\tau > 0$ ). Considering the impact of a trade cost reduction upon the level of the labor tax is a more complex task. From the budget constraint (24), the labor tax in country  $i$  is given by:

$$\tilde{\rho}_i^{uu} = \frac{b_i\tilde{l}_i^u - \tilde{t}^{uu}\tilde{n}_i^{uu}}{\tilde{l}_i^e}. \quad (30)$$

Clearly, trade liberalization may have an ambiguous effect on labor tax at the SPNE. By expanding the tax base ( $\tilde{l}_i^e$ ) and reducing the budget allocated to unemployment benefits ( $b_i\tilde{l}_i^u$ ), trade integration could result in a lower tax burden on labor. Nevertheless, the net effect also depends upon the impact of trade costs on  $\tilde{t}^{uu}$ , the spatial distribution of capital being equal among countries at the SNPE ( $\tilde{n}_i^{uu} = n/2$ ). As corollary of Proposition 3, below the threshold level ( $\bar{\tau}/2$ ), the labor tax unambiguously decreases with trade integration. Above this threshold level,  $\tilde{\rho}_i^{uu}$  may decrease with trade liberalization provided that the wage claims are high enough to give rise to a positive relationship between capital taxation and trade integration. Finally, it is straightforward to check that trade integration effects passing through  $b_i\tilde{l}_i^u$  and  $\tilde{l}_i^e$  are weakened when  $\mu$  tends to zero, as the labor market tends towards a flexible wage setting.

## 5 Asymmetric labor market regimes

Countries can be very different with respect to their labor market institutions, and this could partly explain the variations in labor market performance across different countries

(Blanchard and Wolfers, 2000). In this section, we keep the assumption that monopoly unions are Stackelberg leaders but we analyze tax competition between countries that differ with respect to their labor market institutions. More precisely, we investigate the tax competition outcome between a country with a competitive labor market and a country in which the wage rate is set by a monopoly union.

### 5.1 Capital location and tax base elasticities (stage 3)

We assume that the national wage in country  $F$  is fixed by a monopoly union while there are no labor market imperfections in the other country. The spatial equilibrium  $\lambda^{cu}$  is achieved when  $\Pi_H(\lambda^{cu}) - t_H^{cu} - f w_H^{cu}(\lambda^{cu}) = \Pi_F(\lambda^{cu}) - t_F^{cu} - f w_F^{cu}$ , and given by:

$$\lambda^{cu} = \frac{2l\tau^2 n + w_F^{cu} f (1+n) - (1+n)(t_H^{cu} - t_F^{cu})}{4nl\tau^2 + f^2\eta(1+n)n/l}. \quad (31)$$

It is not surprising that, for given and equal taxes, country  $H$  will host more capital/firms than in the symmetrical configuration ( $\lambda^{cu} > \lambda^{cc}$ ) as long as the wage rate chosen by the monopoly union in country  $F$  is higher than the competitive wage resulting from the competitive labor market ( $w_F^{cu} > \tilde{w}^{cc}$ ).

The tax base elasticities in country  $H$  and  $F$  are expressed as follows:

$$\begin{aligned} \varepsilon_H^{cu}(\tau) &= -\frac{\partial \lambda^{cu}}{\partial t_H^{cu}} \frac{t_H^{cu}}{\lambda^{cu}} = \frac{(1+n)t_H^{cu}}{2l\tau^2 n + w_F^{cu} f (1+n) - (1+n)(t_H^{cu} - t_F^{cu})} \\ \varepsilon_F^{cu}(\tau) &= -\frac{\partial(1-\lambda^{cu})}{\partial t_F^{cu}} \frac{t_F^{cu}}{1-\lambda^{cu}} = \frac{(1+n)t_F^{cu}}{2l\tau^2 n + f(1+n)(f\eta n/l - w_F^{cu}) + (1+n)(t_H^{cu} - t_F^{cu})}. \end{aligned}$$

For each country, we compare the tax base elasticity in the asymmetric configuration with the tax base elasticity that would result if both countries adopted a free labor market institution. Some standard calculations show:

$$\varepsilon_F^{cu} > \varepsilon_F^{cc} \quad (32)$$

$$\varepsilon_H^{cu} \lesseqgtr \varepsilon_H^{cc} \text{ iff } w_F^{cu} \gtrless f\eta n/l = 2\tilde{w}^{cc}. \quad (33)$$

The tax base elasticity of the unionized country is always higher than if there were no labor market imperfections, as is the case for its trading partner. Indeed, following a marginal tax increase in the unionized country, the wage does not shift downward due to the capital outflow, contrary to what happens with a flexible wage setting. Consequently, the capital location is more responsive to a change in tax rate.

It is also worth stressing that tax base elasticity in country  $H$  closely depends upon the wage claims in country  $F$ . When the wage set by the monopoly union is high enough

( $w_F^{cu} > 2\tilde{w}^{cc}$ ), capital invested in country  $H$  has less incentive to relocate in country  $F$  following a rise in  $t_H$ . Hence, by keeping its labor market regime unchanged, country  $H$  can benefit from a lower tax base elasticity when country  $F$  is the single country to move from a free labor market to an unionized labor market.

## 5.2 Nash tax equilibrium (stage 2)

We now describe the Nash tax equilibrium. As the labor market legislation differs between countries, each national government has a different objective function and a different budget constraint. The objective function of country  $H$  is given by (18), whereas the objective function of the government of country  $F$ , which has to deal with unemployment, is given by (25). Moreover, the location equilibrium is now given by (31).

Solving the first-order condition for each government, we get the following Nash tax equilibrium:

$$t_i^{cu} = t^{cc} + \Omega_i(w_F^{cu}, \tau) \quad (34)$$

with

$$\begin{aligned} \Omega_H(w_F^{cu}, \tau) &\equiv \frac{l\tau^2 f(2n+3)(lw_F^{cu} - \eta fn)}{4(4l^2n + 5l^2)\tau^2 + f^2\eta(n+1)^2} \\ \Omega_F(w_F^{cu}, \tau) &\equiv \frac{\eta(1+n)^2 f^2(\eta nf - 3lw_F^{cu}) + l^2\tau^2[(2n+3)\eta nf - (10n+13)lw_F^{cu}]}{4l[\eta f(1+n)^2 + l^2\tau^2(4n+5)/f]} < 0. \end{aligned}$$

It appears that  $t_F^{cu} < t^{cc}$  as long as  $w_F^{cu} > \tilde{w}^{cc}$ . In other words, a shift from a flexible labor market to a unionized labor market in a single country (here country  $F$ ) lowers the capital tax rate in this country. This result arises from the higher tax base elasticity in the latter labor market regime (see (32)) and the need to compensate firms for a labor cost above its competitive level. By contrast,  $t_H^{cu} > t^{cc}$  if and only if  $w_F^{cu} > 2\tilde{w}^{cc}$ . Thus, tax pressure on capital rises in the country which maintains a flexible labor market, provided that its trading partner's union wage is high enough. Indeed, in this case, country  $H$  benefits from both a lower tax base elasticity (see (33)) and a high labor cost in country  $F$ , allowing its government to set higher tax pressure on capital.

It is easy to check that  $t_H^{cu} - t_F^{cu} > 0$  as long as  $w_F^{cu} > \tilde{w}^{cc}$  so that *the existence of trade unions within a country enables its trading partner to set a higher capital tax rate*. Moreover, an increasing wage set by the union in country  $F$  induces a higher tax wedge. Indeed, the labor cost disadvantage being stronger in country  $F$ , its government has to decide on a tax cut to maintain capital while country  $H$  can increase the tax burden on capital. In addition, for a given wage in country  $F$  ( $w_F^{cu}$ ), it is straightforward to check



that  $\partial(t_H^{cu} - t_F^{cu})/\partial\tau > 0$  if and only if  $w_F^{cu} > 2\tilde{w}^{cc}$ . Hence, trade integration favors a lower tax wedge when the wage set by the union reaches high values.

Finally, we know that an increase in  $w_F^{cu}$  negatively (resp. positively) affects the capital tax rate in country  $F$  (resp. in country  $H$ ). Hence, if an increase in  $w_F^{cu}$  favors the location of capital in country  $H$ , that also magnifies the tax wedge and thus indirectly favors the location of capital in country  $F$ . Thus, the effect of the wage set by the monopoly union on the international allocation of capital is ambiguous. At Nash equilibrium tax rates, we obtain the following location equilibrium:

$$\lambda^{cu} = \frac{1}{2} + \frac{f(n+1)^2(lw_F^{cu} - nf\eta)}{4n[f^2\eta(1+n)^2 + l^2\tau^2(4n+5)]} \quad (35)$$

revealing that an increase in  $w_F^{cu}$  favors the location of capital in the country where there are no wage rigidities. In addition, it is worth emphasizing that  $\lambda^{cu} > 1/2$  if and only if  $w_F^{cu} > 2\tilde{w}^{cc}$ . Hence, the country where there are labor market rigidities can accommodate the majority of capital provided that the wage set by the union is not too high.

### 5.3 Equilibrium wage rate (stage 1)

We now solve the first stage of the game. By inserting (35) into the labor demand schedule and by maximizing the union's objective function with respect to  $w_F^{cu}$ , we get the following equilibrium wage rate in the unionized country:

$$\tilde{w}_F^{cu} = \bar{w} + \mu \left( \frac{3f\eta n}{l} - \bar{w} \right) + \mu \frac{2l\tau^2 n(4n+5)}{(1+n)^2 f} \quad (36)$$

which is increasing with trade costs ( $d\tilde{w}_F^{cu}/d\tau > 0$ ). By introducing (36) in (34), it appears that the impact of trade costs on the capital tax rates is ambiguous. Indeed, we have

$$(a) \frac{d\tilde{t}_H^{cu}}{d\tau} = \frac{d\tilde{t}^{cc}}{d\tau} + \frac{d\Omega_H(\tilde{w}_F^{cu}, \tau)}{d\tau} \quad (b) \frac{d\tilde{t}_F^{cu}}{d\tau} = \frac{d\tilde{t}^{cc}}{d\tau} + \frac{d\Omega_F(\tilde{w}_F^{cu}, \tau)}{d\tau} \quad (37)$$

Hereafter, we make the standard assumption that the reservation wage is just equal to the competitive wage arising from competitive labor markets in both countries ( $\bar{w} = \tilde{w}^{cc}$ ).

We should recall that the first term in (37-a) and (37-b) is not affected by wage rigidities in country  $F$  and describes a non-monotonous relationship between the level of taxation and trade costs (see Section 3.3). The second term defines an additional effect of trade integration passing through the labor market in country  $F$ . Thus, it is easy to check that  $\Omega_F$  rises when  $\tau$  becomes lower. This effect reveals the negative impact of trade integration upon the wage claim of the union in country  $F$  which allows its government to

make upwards adjustments of capital taxation. Finally, we verify that the total effect of trade openness on the capital tax rate in the unionized country is positive provided that trade costs are low enough ( $\tau < \bar{\tau}/2$ ) or, otherwise, when the union sufficiently values wages over employment. For instance, assuming a rent maximization behavior ( $\mu = 1/2$ ), the capital tax rate prevailing in country  $F$  always increases with trade integration.

The effect of trade integration upon tax burden on capital located in the non-unionized country differs. Indeed, as trade integration gives rise to a fall in the cost of labor in the unionized country, the government of country  $H$  has an incentive to make a downwards adjustment of its taxation. For instance, assuming a rent maximization behavior ( $\mu = 1/2$ ),  $\Omega_H$  is continuously decreasing with trade liberalization. In this case, provided that  $\tau > \bar{\tau}/2$ , capital taxation always adjusts downward with reduced trade costs as both  $t^{cc}$  and  $\Omega_H$  diminish with lower levels of  $\tau$ . For  $\tau < \bar{\tau}/2$ , trade liberalization generates two effects which act in opposite directions and the net effect becomes ambiguous. Nevertheless, for the most general case ( $\mu \in (0, 1)$ ), trivial calculations reveal that  $d\tilde{t}_H^{cu}/d\tau > 0$  is more likely to occur when decreasing trade costs lead to an important erosion of the wage set by the monopoly union in country  $F$ , that is when  $\mu$  and  $\tau$  take initially high values. In this case, a downwards adjustment of capital taxation in country  $H$  is the best response to a more and more ompetitive labor cost in country  $F$  even if the latter country may simultaneously make an upwards adjustment of its taxation.<sup>16</sup>

The impact of trade costs upon the tax wedge can be described as follows  $d(\tilde{t}_H^{cu} - \tilde{t}_F^{cu})/d\tau = d(\Omega_H - \Omega_F)/d\tau$ . Trivial calculations show that  $d(\tilde{t}_H^{cu} - \tilde{t}_F^{cu})/d\tau \gtrless 0$  when  $\mu \gtrless \hat{\mu}$  with:

$$\hat{\mu} = \frac{(1+n)^4 \eta^2 f^4}{f^4 (48n+65) (1+n)^4 \eta^2 + 16l^2 \tau^2 (3n+4) (4n+5) [2f^2 \eta (1+n)^2 + l^2 \tau^2 (4n+5)]}$$

We check that  $\hat{\mu}$  is strictly decreasing with  $\tau$  and equals  $1/(65+48n)$  when trade integration is perfect ( $\tau = 0$ ). Consequently, for a very large range of  $\mu$  values and, for example, when  $\mu = 1/2$ , trade integration induces a fall in the international corporate tax wedge. This result is consistent with the analysis above where we show that a decrease in trade costs is more likely to lead to a higher level of capital taxation in country  $F$  and a lower level in country  $H$ .

We now turn to the location of firms at the SPNE. One key question we have to

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<sup>16</sup>To understand this result, we should observe that  $d^2\Omega_H/dw_F^{cu}d\tau$ ,  $d^2w_F^{cu}/d\tau^2$  and  $d^2w_F^{cu}/d\tau d\mu$  are all positive. Thus, a strong preference for wages over employment and high trade costs foster the positive impact of trade costs upon the capital tax in country  $H$ . It is intuitive since both parameters  $\tau$  and  $\mu$  increase the importance of the wage level in country  $F$  for the tax policy in country  $H$ .

address is whether or not country  $F$  can be a net-importer of capital or host a majority of firms despite the rigidities on its labor market. By inserting the equilibrium level of  $\tilde{w}_F^{cu}$  into the location equilibrium (35), we get  $\tilde{\lambda}^{cu} \geq \frac{1}{2}$  if and only if

$$\mu \geq \bar{\mu} = \frac{f^2 \eta (n+1)^2}{4l^2 (4n+5) + 5f^2 \eta (n+1)^2}$$

Clearly, the country with labor market rigidities may host a majority of firms ( $\tilde{\lambda}^{cu} < 1/2$ ). Such a scenario occurs when the relative importance of wages over employment for the trade union and the resulting wage equilibrium are not too high (low  $\mu$ ). It is excluded, for instance, when we assume the rent maximization hypothesis. In which case, country  $F$  is a net-exporter of capital because the level of capital taxation in this country is always insufficient to compensate firms for high labor costs and to render this country more attractive. Interestingly, it gives us a new insight into the locational effects of tax competition. Indeed, a standard result in the tax competition literature with perfect competition and countries with asymmetric sizes is that the country with the lowest capital taxation (the small country) will always be a net-importer of capital (see Wilson and Wildasin, 2004, Bucovsky, 1991). This result is commonly challenged in the New Economic Geography models where, thanks to the existence of an agglomeration rent, the large country is not only the country with the lowest capital taxation but also a net-importer of capital. Here, we show that, by considering an asymmetry not as exogenous (market sizes) but rather as endogenously determined by the behavior of a monopoly union acting as Stackelberg leader, both scenarios can occur.

Finally, we observe that the mass of capital within the country with a free labor market decreases with trade integration ( $d\tilde{\lambda}^{cu}/d\tau > 0$ ). This result comes from the different impact of trade integration upon wages in each country. Indeed, the competitive wage in country  $H$  decreases with trade integration but less strongly than the wage in the unionized country so that trade integration induces a wage convergence ( $d(\tilde{w}_F^{cu} - \tilde{w}_H^{cu})/d\tau > 0$ ). Hence, on the one hand trade integration reduces the ‘fiscal’ incentive to locate in the unionized country whilst, on the other hand, the ‘labor cost’ is an incentive to locate in the country with a competitive labor market. As the mass of capital invested in country  $H$  decreases with trade integration, we can conclude that the second effect is dominant.

**Proposition 4** *Assume a monopoly union in one country whereas the labor market of the other country is competitive. Due to capital tax competition, the unionized country sets a lower capital tax and attracts a higher share of capital provided that the relative*

*importance of wages over employment for the monopoly union is not too high. The mass of capital invested in this country increases with trade integration.*

## 6 Discussion

Until now, we considered the trade unions to be acting as Stackelberg leaders. In the appendix, we present the results with two alternative timings of events: when governments act as Stackelberg leaders (as in Palokangas, 1989, Fuest and Huber, 1999) and when governments and trade unions play simultaneously. For the latter configuration, the four propositions still prevail, although proposition 3 is affected when governments act as Stackelberg leaders for trivial reasons. Indeed, when both labor markets are unionized and governments are Stackelberg leaders, equilibrium taxes follow a J-shaped relationship with trade integration ( $d\tilde{t}_i^{uu}/d\tau \geq 0$  when  $\tau \geq \bar{\tau}/2$ ), as they do when labor markets are competitive. This result is very intuitive. Since the tax equilibrium does not depend upon the unions' wage claim, trade integration does not have a positive indirect effect upon capital taxation through the wage rate set by unions. No forces affect the J-shaped relationship also obtained with flexible labor markets. Such a result differs from the case where the union is the first mover. Nevertheless, as soon as monopoly unions have different preferences for wages over employment ( $\mu_H \neq \mu_F$ ), the tax reaction functions are no longer perfectly symmetrical and both preferences are important for the level of the tax equilibrium. In this case, trade integration affects capital taxes through its effect on the labor market outcome that governments anticipate. The other propositions (1, 2 and 4) remain valid when governments act as Stackelberg leaders.

Another question we can raise is whether or not results would hold under another kind of wage rigidity. Following Ogawa *et al.* (2006), we also parametrized labor market rigidities in a simple and extreme way, by considering that the wage rate in each country is set exogenously at a level  $\omega$  higher than the competitive wage. This wage rigidity being exogenous and thus independent of trade integration, we cannot discuss proposition 1 anymore and intuitively, capital taxes follow a J-shaped relationship with trade integration, as when labor markets are competitive. Nevertheless, proposition 2 and 4 remain valid. A shift from a flexible labor market to a labor market with a rigid wage reduces business tax rates, because of the higher tax base elasticity and the higher cost of labor. Finally, when there is an exogenous wage rigidity in only one country, we still observe that its government sets a lower capital tax and, by so doing, is able to successfully attract a majority of capital provided that the national wage is not too high. In such a case, we

also observe that trade integration improves the attractiveness of the country suffering from unemployment. Thus, proposition 4 still prevails.

## 7 Conclusion

Unemployment might be one of the major reasons behind why governments try to attract firms through their tax policy. In this paper, we have explored the relationship between labor market imperfections and tax competition in a framework with imperfect competition and trade costs. Our results can be summarized as follows. Firstly, we show that labor market imperfections in both countries strengthen tax competition as compared with the case where both labor markets are competitive. Secondly, the impact of trade integration on tax policies depends on the configuration of the labor market. When the labor market is competitive, capital taxes follow a J-shaped relationship with trade costs. By contrast, when labor markets are unionized and preferences of union for wage over employment are high enough, capital taxes may increase with trade integration whatever the level of trade costs. This result is valid when trade unions act as Stackelberg leaders and when trade unions and governments act simultaneously. We also analyze the tax competition outcome in the asymmetric case where the labor market is competitive in one country and unionized in the other one. We show that the capital tax rate is lower in the unionized country and that a majority of capital can locate there under certain circumstances.

Of course, this model is stylized and ignores important aspects of the wage formation process. It would be interesting to model wage bargaining in a more general case where both unions and firms have bargaining power. Moreover, a welfare analysis is needed in order to know whether tax competition is welfare-enhancing or not when faced with labor market imperfections. This welfare analysis is left for further work.

Finally, although our paper is motivated by empirical facts reported in the introduction, an econometric analysis is needed to support our main findings. More precisely, by following the literature on tax interactions (Devereux *et al.*, 2008), a tax reaction function could be estimated. It would consist of regressing corporate taxes on indicators of trade openness, on labor market rigidities and on the interaction of these two variables.

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## Appendix

**A- Governments and trade unions play Nash.** Let us first assume that governments and unions act simultaneously. Thus, each government and each union chooses its policy by anticipating the location of capital.

**Symmetric tax competition.** The product market outcome at the fourth stage of the game is described in section 3.1.1. and the location equilibrium for given taxes and wages is given by (22). We now solve the last stage of the game where monopoly unions and governments set wages and tax rates respectively. The monopoly union in country  $i$  determines  $w_i^{uu}$  to maximize  $U_i = (w_i^{uu} - \bar{w})^\mu (L_i^d)^{1-\mu}$ , with  $L_i^d = fn\lambda_i^{uu}$  while the maximization program of each government is given by:

$$\max_{t_i^{uu}} W_i^u = lS_i^* + \frac{r^*n}{2} + t_i n \lambda_i^{uu} + \frac{1}{2} \frac{(w_i^{uu})^2}{\eta} l_i^e + \text{constant}$$

The labor demand elasticity to the wage rate in country  $i$  is now given by:

$$\xi_i = \frac{f(1+n)w_i^{uu}}{2nl\tau^2 + (1+n)(fw_j^{uu} - fw_i^{uu} + t_j - t_i)}$$

where  $d\xi_i/d\tau$  is still negative. The new effect lies in the fact that the labor demand elasticity in a country increases with its capital tax rate. Consequently, the higher the capital tax, the more the trade union is prompted to lower the wage rate in order to reduce the negative impact of its intervention on the level of employment.



The equilibrium tax and wage levels are given by:

$$\begin{aligned}\tilde{t}_i^{uu} &\equiv \tilde{t}^{cc} - \frac{f\bar{w}}{2} - \frac{\mu}{1-\mu} \frac{l\tau^2 n}{1+n} \quad \forall i = H, F \\ \tilde{w}_i^{uu} &= \bar{w} + \frac{\mu}{1-\mu} \frac{2ln\tau^2}{f(1+n)} \quad \forall i = H, F\end{aligned}$$

First, observe that Proposition 1 and 2 are not altered as we check that  $\partial \tilde{w}_i^{uu} / \partial \tau > 0$  and  $\tilde{t}_i^{uu} < \tilde{t}^{cc}$ . Secondly, note that  $\partial \tilde{t}_i^{uu} / \partial \tau < 0$  when  $\mu > [a - \tau(3+2n)] / [a - \tau(5+4n)] \in (0, 1)$ . Consequently, trade integration can give rise to higher corporate taxes. This will be the case if  $\tau > \bar{\tau}/2$  and  $\tau < a/(5+4n)$  provided that  $\mu$  is high enough and if  $a/(5+4n) < \tau < \bar{\tau}/2$  for all values of  $\mu \in (0, 1)$ . Thus, the main result mentioned in Proposition 3 - the possibility for trade integration to relax tax competition when trade unions have a strong preference for wages compared to employment - is checked.

**Asymmetric tax competition.** The product market outcome at the fourth stage of the game is described in Section 3.1.1 and the equilibrium location is given by (31). By solving the maximization program of the monopoly union in country  $F$  and the maximization program of governments, we obtain the following tax wedge at equilibrium:

$$\tilde{t}_H^{cu} - \tilde{t}_F^{cu} = \frac{n[f^2\eta(1+n) + 4l^2\tau^2]}{2(1+n)l} \frac{(12l^2 + 8l^2n)\tau^2 + 3f^2\eta(n+1)^2\mu + (1+n)^2f^2\eta}{(4-3\mu)\eta(1+n)^2f^2 + l^2\tau^2(4n+5-\mu(3n+4))} > 0.$$

so that the location equilibrium at the SPNE is described by:

$$\begin{aligned}\tilde{\lambda}^{cu} &= \frac{1}{2} + \frac{f^2\eta(1+n) - 2\mu(\eta f^2(n+1) + 2l^2\tau^2)}{(4-3\mu)\eta(1+n)^2f^2 + l^2\tau^2(4n+5-\mu(3n+4))} \geq \frac{1}{2} \\ \text{when } \mu &\geq \dot{\mu} = \frac{f^2\eta(1+n)}{2f^2\eta(1+n) + 4l^2\tau^2} > \bar{\mu}\end{aligned}$$

and with  $(d\tilde{\lambda}^{cu}/d\tau > 0)$ . Thus, proposition 4 still holds.

Evaluating the competitive wage in country  $F$  at this location equilibrium, gives us:

$$\tilde{w}_F^{cu} = \bar{w} + \frac{\mu n}{2(1+n)l} \frac{[f^2\eta(1+n) + 4l^2\tau^2](5\eta f^2(n+1)^2 + 4\tau^2l^2(4n+5))}{(4-3\mu)\eta(1+n)^2f^2 + l^2\tau^2(4n+5-\mu(3n+4))} > \tilde{w}_H^{cu}.$$

Hence, the competitive wage is lower than the wage level set by monopoly union in country  $F$ . Moreover, it is lower than when the monopoly union in country  $F$  acts as a Stackelberg leader.

**B- Governments act as Stackelberg leaders.** Let us now consider that in the first stage, each government chooses its tax policy by anticipating the wage set by unions and

the location of capital. In the second stage, each monopoly union chooses its wage level, taking governments' tax policies as given, and anticipating the impact of their choice on the location of capital. The following stages of the game remain unchanged.

**Symmetric tax competition.** The product market outcome at the fourth stage of the game is described in section 3.1.1. whereas the location equilibrium for given taxes and wages is given by (26). We now solve the second stage of the game where monopoly unions set their level of wages, taking tax choices of governments as given and anticipating the resulting private sector outcome. The monopoly union in country  $i$  determines  $w_i^{uu}$  to maximize  $U_i = (w_i^{uu} - \bar{w})^\mu (L_i^d)^{1-\mu}$  with  $L_i^d = fn\lambda_i^{uu}$ , taking  $w_j^u$  as given as well as  $t_i$  and  $t_j$ . The fact that the government acts as a Stackelberg strengthens the labor demand elasticity to the wage rate. Thus we obtain:

$$\xi_i = \frac{f(1+n)w_i^{uu}}{2nl\tau^2 + (1+n)(fw_j^{uu} - fw_i^{uu} + t_j^{uu} - t_i^{uu})}$$

with  $d\xi_i/d\tau < 0$ ,  $d\xi_i/dt_i^{uu} > 0$  and  $d\xi_i/dt_j^{uu} < 0$ . The higher the capital tax in a country, the more the trade union of this country will tend to lower the wage rate in order to limit the negative impact of its intervention upon the level of employment.

Solving the union's maximization program for each country leads to the following equilibrium wage:

$$w_i^{uu} = \bar{w} + \frac{\mu}{1-\mu} \frac{2nl\tau^2}{f(1+n)} + \frac{\mu}{1+\mu} \frac{t_j^{uu} - t_i^{uu}}{f} \quad (38)$$

As expected, the level of wage chosen by a monopoly union in a country decreases with the capital tax rate in this country and increases with the capital tax rate in the other country.

We can now solve the maximization program of each government:

$$W_i^{uu} = LS_i^* + \frac{r^*n}{2} + t_i n \lambda_i^{uu} + \frac{1}{2} \frac{(w_i^{uu})^2}{\eta} l_i^e + \text{constant}.$$

Because each government anticipates the impact of its tax policy upon the labor market outcome, there is an additional incentive to decrease the capital tax in order to increase the equilibrium wage rate and to reduce the unemployment rate through a capital inflow.<sup>17</sup> On the other hand, each government also has an additional incentive to increase capital taxation in order to reduce the unemployment rate through the wage decrease set by the

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<sup>17</sup>By evaluating the spatial equilibrium at the level of wages set by monopoly unions, we check that a unilateral increase in capital taxation induces a capital outflow even if it lowers the national wage rate.

union. The tax reaction function of each country is given by

$$t_i^{uu} = \frac{2(1+\mu)n + 3 + \mu}{6(1+\mu)n + 7 + 5\mu} t_j^{uu} + \Phi(\mu, \tau)$$

These functions reveal that the impact of  $t_j^{uu}$  upon  $t_i^{uu}$  is positive and is negatively affected by  $\mu$ . Because however,  $\mu$  is identical in both countries and enters symmetrically into the tax reaction functions, we obtain the following tax equilibrium:

$$\tilde{t}_i^{uu} = \tilde{t}^{cc} - \bar{w}f/2 \quad \forall i = H, F. \quad (39)$$

Again, capital taxes are lower than when labor markets are competitive so that proposition 2 remains valid. Moreover, they are higher than when monopoly unions act as Stackelberg leaders (see ??)<sup>18</sup>.

Finally, inserting these equilibrium taxes (39) in (38), we get the equilibrium wage rate in each country at the SPNE:

$$\tilde{w}_i^{uu} = \bar{w} + \frac{\mu}{1 - \mu} \frac{2ln\tau^2}{f(1+n)} \quad \forall i = H, F.$$

Again,  $\tilde{w}_i^{uu}$  decreases with trade integration and Proposition 1 still holds. Moreover, since governments set higher taxes when they act as Stackelberg leaders, the equilibrium wage set by monopoly unions at the following stage is lower than its level when they take their decision before governments.

**Asymmetric tax competition.** We now present the result for the asymmetric configuration where the labor market is competitive in country  $H$  while it is unionized in country  $F$ . The product market outcome at the fourth stage of the game is described in Section 3.1.1. We first solve the second stage of the game where the monopoly union in country  $F$  chooses the level of the national wage, taking tax choices of governments as given and anticipating the resulting private sector outcome.

The monopoly union in country  $F$  sets  $w_F^{cu}$  to maximize  $U_F = (w_F^{cu} - \bar{w})^\mu (L_F^d)^{1-\mu}$  with  $L_F^d = fn(1 - \lambda^{cu})$  where  $\lambda^{cu}(t_H^{cu}, t_F^{cu}, w_F^{cu})$  is given by (32). Solving this maximization program, we obtain:

$$w_F^{cu} = (1 - \mu) \bar{w} - \mu \frac{l(1+n)(t_F^{cu} - t_H^{cu}) - n(2l^2\tau^2 + f^2\eta(1+n))}{lf(1+n)}. \quad (42)$$

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<sup>18</sup>The intuition for this result comes from the lower tax base elasticity when governments act as Stackelberg leaders. Indeed, the tax base erosion effect is limited by the fact that an increase in capital taxation is partly compensated by the decrease in the wage rate set by monopoly unions. By contrast, when governments set their tax policy after trade unions have decided the level of wages, this wage adjustment does not exist so that an increase in capital taxation induces a more important capital outflow.

Assuming that the reservation wage is equal to  $\tilde{w}^{cc}$  and solving the maximization program of governments, we reach the following equilibrium tax gap:

$$\tilde{t}_H^{cu} - \tilde{t}_F^{cu} = \frac{n[f^2\eta(1+n) + 4l^2\tau^2]}{8(1+n)l} \frac{\eta(1+\mu)(1+n)^2 f^2 + 4l^2\mu\tau^2(2n+3-\mu)}{(1-\mu)[\eta(1+n)^2 f^2 + l^2\tau^2(4n+5-\mu)]} > 0.$$

Hence, we can describe the location equilibrium at the SPNE:

$$\tilde{\lambda}^{cu} = \frac{1}{8} \frac{3\eta(1+n)^2(1+\mu)f^2 + 4l^2\tau^2[6\mu(1+n) + (5+4n)(1-\mu)]}{\eta(1+n)^2 f^2 + l^2\tau^2(4n+5-\mu)} \geq \frac{1}{2}$$

when  $\mu \geq \check{\mu} \equiv \frac{f^2\eta(1+n)}{3f^2\eta(1+n) + 8l^2\tau^2} > \bar{\mu}$

and we check that  $d\tilde{\lambda}^{cu}/d\tau > 0$ . Hence, proposition 4 is still valid.

By evaluating the competitive wage in country  $H$  at this location equilibrium, we have:

$$\tilde{w}_H^{cu} = \frac{nf\eta}{8l} \frac{4l^2(2n\mu + 4n + 5 - \mu)\tau^2 + 3f^2\eta(1+n)^2(1-\mu)}{l^2(4n+5-\mu)\tau^2 + f^2\eta(1+n)^2} < \tilde{w}_F^{cu}.$$

As in the benchmark case, the competitive wage is lower than the level of wage set by monopoly union in country  $F$ . Moreover, it is lower than when the monopoly union in country  $F$  acts as a Stackelberg leader.